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CHEMISTRY IN RELATION TO BIOLOGY AND MEDICINE WITH ESPECIAL REFERENCE TO INSULIN AND OTHER HORMONES[1]

YOUR speaker to-day is one who is primarily a worker in the field of experimental medicine; a chemist, if at all, only in so far as an imperfect mastery of your science became necessary for the solution of physiological and pharmacological problems that could not be undertaken or even formulated if their chemical aspects were to be ignored. Under the circumstances I can but feel a sense of deep unworthiness in venturing to address an audience in which are gathered so many distinguished representatives of your noble science. I am highly appreciative of the signal honor conferred upon me by the board of award of the Chicago Section of the American Chemical Society in the bestowal of the Willard Gibbs Medal and I beg the members of the board to believe that I am duly grateful to them.

There exists in our day an essential unity of outlook and interest among the majority of professional chemists, biologists and medical men in respect to the physical and chemical aspects of life. This unity of interest and unanimity of opinion in respect to the applicability of the laws of physics and chemistry to the elucidation of vital processes have their origin far in the past and date from a time long before chemistry had attained to its present dignity as an independent science. It is not my purpose to attempt to record even briefly the history of chemistry or that of medicine, subjects that have been so well treated by many learned men of both professions, but I would ask your forbearance toward an imperfect sketch of the points of contact between your professional ancestors and mine. I leave out of consideration here any reference to such contacts in the ancient or later alchemical periods, or to Arabian science in Western Europe, further than to remark that alchemy, which at its best combined far-reaching metaphysical speculations with a crude experimental chemistry, had, as one of its several aims, not alone the transmutation of the baser metals into gold, thus abolishing that "great disease, poverty," but also

[1] The Willard Gibbs lecture delivered before the Seventh Midwest Intersectional Meeting on the occasion of the award of the Willard Gibbs Gold Medal by the Chicago Section of the American Chemical Society, May 27, 1927.

the cure of fleshly ills and the gift of "perfect health and length of days." Certainly the search throughout the long alchemical period for the "elixir of immortal health" supports the claim for this medical aspect of alchemy, even without proofs on the literary side.

To-day the modern alchemists among you have, in a most remarkable manner and in a most concrete way, actually realized the age-long dream of your predecessors. Paneth well describes the chemical and the medical actions of the modern philosophers' stone, radium, in the following words:

> Thus we see that in a certain sense radium possesses the first and principal property ascribed to the philosophers' stone: it has the power of transmuting elements, although not of producing gold. And, oddly enough, even in respect to the second property which was ascribed to the philosophers' stone radium seems to have gotten something from its fabulous predecessor: it is a very valuable aid in the treatment of some severe diseases, although not a perfect remedy for every illness. So that to a certain degree the radium rays really produce the two very different effects of the philosophers' stone, transmutation and healing.

Even in the later alchemical period the older professions of medicine and pharmacy furnished opportunity, though often grudgingly given, for the development of chemistry, and they may justly be said to have been the parents of modern chemistry. Throughout this period, as in ancient times, there existed a large number of industries, such as the metallurgical industries, enamel- and glass-making, painting, brewing and wine-making, to give only a few examples. But the practice of these ancient arts could not lead to the development of a chemical science as long as the true character of organic principles of the elements and their compounds remained unknown. Especially close was the connection between chemistry and medicine in the days of the iatro- or physician-chemists of the sixteenth and seventeenth centuries. In the first half of the sixteenth century, at a time when the crude chemistry of that day was still entangled with the traditions and even downright impostures of alchemy, there appeared an extraordinary man, Paracelsus (1493–1541), "the very incarnation of the spirit of revolt" (Osler), who must indeed be regarded as one of our ancestors in both branches of learning. Remember that in his day medicine was already a long established and powerful profession and this bold innovator in chemical physiology, pathology and pharmacology, who heaped scorn on Galen and Avicenna, very naturally aroused the hostility of many of the leading physicians of the day.

He is the most notable figure among the earlier physician-chemists and, in the words of the historian E. v. Meyer, to him belongs incontestably the credit of fusing chemistry and medicine in the first half of the sixteenth century, of forcing both into new paths and of freeing chemistry from the shackles of alchemy. Up to our time some of his writings have appeared in no less than five hundred editions. He declared it the true purpose of chemistry not to be the making of gold but the preparation of medicines. "Alchemy is neither to make gold nor silver: its use is to make the supreme sciences and to direct them against disease." This too narrow a conception of the science was soon to be broadened out by the iatro-chemists of the century and more, following his death. He stated clearly that the processes of the animal organism are chemical in their nature and that health is a function of, or dependent on, the composition of the juices and tissues of the body. Even in regard to the rôle played by air in respiration, I find Robert Boyle, more than a century later, citing him in support of his own views, as saying "that as the stomach concicts meat and makes part of it useful to the body, rejecting the other part, so the lungs consume part of the air and proscribe the rest." Medical historians have occupied themselves more with an analysis of the medical achievements of Paracelsus, the Luther of medicine (Osler), than with his chemical discoveries, and his significance is perhaps greater for medicine than for chemistry. He is certainly of great importance in the history of chemical therapeutics and pharmacology. Sudhoff says of his work in these fields:

> He was the first one to show how to separate the active principles from drugs and to use them in tinctures and extracts. He made important discoveries in chemistry: zinc, the various compounds of mercury, calomel, flowers of sulphur, among others, and he was a strong advocate of the use of preparations of iron and antimony. In practical pharmacy he has perhaps had a greater reputation for the introduction of the tincture of opium—"labdanum" or laudunum—with which he effected marvelous cures and the use of which he had probably learned in the East (Osler).

Naturally, I can not pause to give more than a very incomplete sketch of this innovator whom I here mention because of his constant insistence that physiological processes are chemical processes and that drugs by their chemical properties can bring about favorable chemical alterations in a diseased body.

It has for many years been a custom with me to characterize the vital importance of certain defensive substances and the products of internal secretion present in our bodies in the aphorism: We are walk-

g drug stores. On reading Sudhoff's reprint of the *abyrinthus medicorum errantium* of Paracelsus 1538), a little meaty classic, I was delighted to find at four centuries ago our author had already elaboated this idea at length:

> Also in human beings there is a natural apothecary in hich are found all things as in the world (the macrosm), good and bad, simples and composites, however ey be named. . . . As the outer world, the macrocosm, ntains visible pharmacies and visible physicians, so in e microcosm, that is to say, in the human being, there present an invisible pharmacy and an invisible physian who produces, prescribes, dispenses and administers itable remedies as occasion demands. . . . Let it be nown to all men then that had not God created and laced in the bodies of men natural remedies and a natral physician, then, notwithstanding all the efforts of ur physicians, not a single creature of earth would reain alive.

In this quite modern fashion Paracelsus here retates the enduring canon of Hippocrates—Νούσων ύσιες ιατροί—better known to us in its later paraphrased form as *vis medicatrix naturae*. Professor Max Neuburger, the learned professor of the history of medicine at Vienna, truly remarks that the problem of nature's healing power is probably the most weighty of all that have engaged the thoughts of physicians during thousands of years.

The iatro-chemists were the physiological chemists of their day. They possessed the highest scientific and humanistic culture of the time and historians of science agree in the opinion that chemistry profited greatly by passing into their hands. The study of their attempts to elucidate the phenomena of life and the chemical alterations associated with disease is a fascinating one. The physiologists, biochemists and pharmacologists of our day have at their disposal a great wealth of discovery in the more exact sciences—the gifts of the intervening centuries, but even with all this assistance modern iatro-chemists still find themselves trying, though confidently, to hack their way out of the jungle so boldly and gaily entered by their predecessors nearly three hundred years ago.

Naturally you will call to mind also, as every one must, the iatro-physicists of this period. It is thought that the physiological speculations of Descartes, as given in his treatise *De Homine*, had a great influence in turning men's minds to the possibility of basing physiology on physics and chemistry, but there is little doubt that the teachings and discoveries of Harvey had the greater influence on the development of iatro-physics. This phase of science, however, lies outside our present discussion.

I must content myself with recalling to your minds a few of the names of the iatro-chemists of this period —van Helmont and Sylvius, of whom Michael Foster, with a first-hand knowledge of their writings and those of their pupils, has given such an enlightened and sympathetic account in his Lane Lectures on the History of Physiology in the sixteenth and seventeenth centuries—Tachenius, Willis, Mayow, Lémery, Hooke, Peyer, Brunner and many others of this time might be named who forwarded both chemistry and medicine in the latter half of the sixteenth and well on into the seventeenth century.

One great man, Robert Boyle, nobleman of wealth, stands out prominently in the seventeenth century, one whose name is revered alike by physicists, chemists and medical investigators. This greatest chemist of his day, though not trained as a medical man, nevertheless, says one of his biographers, Thomas Birch, "went very accurately through all the parts of Physic." A study of his writings furnishes ample evidence of his acquaintance with medicine and the medical theories of his day. This great man even occupied himself with therapeutical questions and published "collections of choice and safe remedies, for the most part simple and easily prepared, very useful in families and fitted for the service of country people." The historian Neuburger in his scholarly treatise entitled "Die Lehre von der Heilkraft der Natur im Wandel der Zeiten" devotes several pages to Boyle's views in regard to the respective rôles of "nature" and the physician "in restoring the distempered body to its pristine state of health," and states that Boyle's opinions on these matters were not without value and precipitated many controversies.

Boyle was particularly fascinated by that fundamental problem—the nature of the respiratory process —of which he says that "it is a subject of that difficulty to be explained and yet of that importance to human life that I shall not regret the trouble my experiments have caused me if they are found in any degree serviceable to the purpose for which they were designed." I have been surprised to learn, in my study of his writings, with what ardor Boyle pursued the effects of diminished air pressure, with his improved Guericke "pneumatic machine," on a great variety of animals. Bees, flies, butterflies, caterpillars, humming birds, sparrows, larks, mice, fishes, eels, unborn puppies, all served as objects of experiment in the study of this great problem which was to occupy the attention of his successors down to our day. At a time when, in spite of some earlier approaches to the truth, it was still generally held that the sole purpose of breathing is to cool the blood,

Boyle's experiments forced upon him the conviction expressed as follows:

> Without denying that the inspired and expired air may be sometimes very useful by condensing and cooling the blood that passes through the lungs, I hold that the depuration of the blood in that passage is not only one of the ordinary, but one of the principal uses of that passage. But I am also apt to suspect that the air doth something else in respiration which hath not yet been sufficiently explained.

The last sentence suggests that Boyle may have had a prevision, years before the discovery of oxygen, that this "something else" is the respiration of the tissues themselves.

After citing the opinion of Paracelsus, an opinion not based on experimental evidence, that "the lungs consume part of the inspired air and proscribe the rest," Boyle, on the basis of his own extensive experimentation, makes the prophetic statement:

> It seems we may suppose that there is in the air a little vital quintessence, if I may so call it, which serves to the refreshment and restauration of our vital spirits, for which use the grosser and incomparably greater part of the air being unserviceable, it need not seem strange that an animal stands in need of almost incessantly drawing in air.

This "vital quintessence" is of course the later oxygen of Priestley and Scheele.

All of his experiments lead him to support

> the theory of Moebius that the genuine use of respiration is the ventilation not of heart but of the blood in its passage through the lungs, in which it is disburthened of those excrementitious steams proceeding for the most part from the superfluous serosities of the blood.

Truly, Boyle could touch no subject without leaving his mark on it. For example, the respiration of fishes, "being animals without lungs," also excited his curiosity, and he "thinks it not altogether absurd to say that their gills seem somewhat analogous (as to their use) to lungs." His experiments with the air pump had taught him that there is "wont to lurk in water many little parcels of interspersed air, whereof it is not impossible that fishes may make some use, either by separating it when they strain the water through their gills or in some other way."

Time and occasion permit only of a glance at a few other great peaks in the panorama that we are so hastily surveying. Let us pass at once from Boyle to Lavoisier, another immortal, one of the greatest among the founders of your science, often, indeed, called the creator of modern chemistry, but also one who made fundamental contributions to the theory of respiration. He mistakenly held that combustion occurs only in the lungs. Thus, in the well-known joint memoir with the great mathematician Laplace, published in 1780, the conclusion is arrived at:

> Respiration is therefore a combustion, slow, it is true, but otherwise perfectly similar to the combustion of charcoal. It takes place in the interior of the lungs without giving rise to sensible light because the matter of the fire (the caloric), as soon as it is set free, is forthwith absorbed by the humidity of these organs. The heat developed by this combustion is communicated to the blood which is traversing the lungs, and from the lungs is distributed over the whole animal system (Foster's translation).

In spite, however, that the place where oxidation occurs is erroneously inferred to be in the lungs only rather than in the hidden recesses of the tissues of the body, Lavoisier is nevertheless the first chemist or physiologist to *prove* that the respiration exchange is the result of a combustion and he was the first to make quantitative measurements during respiration of the intake of the "respirable part" of the atmosphere (the oxygen of Scheele and Priestley, later so named by Lavoisier) and of the output of the "aeriform calcic acid" (the carbon dioxide or "fixed air" of Black). It is quite comprehensible that the creator of gravimetric analysis and the discoverer of the principle of the conservation of mass in chemical operations should have made this quantitative experiment in animal physiology.

There is not time while we are on this subject of the respiration to consider the work of Joseph Black, Robert Hooke, Richard Lower and others of that time. The physician-chemist John Mayow (1643–79), however, can not be passed over without a word. Like Boyle, Mayow saw clearly that respiration is supported, not by the air as a whole "but by the more active and subtle part of it, the spiritus nitro-aerius," or spiritus igneo-aerius, and both by experiment and inference demonstrated the analogy between respiration and combustion. The increase of weight attending the calcination of metals he declares also as due to the absorption of the *spiritus* of the air. Mayow had sound notions in regard to the relation between increased muscular work and increased respiration a full century before Lavoisier and Priestley, but unfortunately, in conformity with the conceptions of his day, he states that his nitro-aerial spirit is separated from the blood in the ventricles of the brain and passes thence in supposed nerve tubules to the muscles where it combines with "sulphur," in consequence of which union muscular contraction results. The numerous and ingenious experiments of Priestley (1733–1804), one of the last

phlogistonists, on respiration, combustion and calcination, as detailed in his memorable treatise, Experiments and Observations on Different Kinds of Air (1774), must also be passed over.

The latter part of the eighteenth and the first quarter of the nineteenth century were days of great discoveries of inestimable value to mankind, discoveries that inevitably and finally raised chemistry to the status of a great science, a younger sister of physics, though in our day the exponents of the older science claim, and perhaps justly so, that your science will ultimately be incorporated into the body of physics and that instead of atomists you will become mathematical energeticists, dealing primarily with protons and electrons and quanta and other concepts of their wizardry.

In this period the elemental or composite character of the various "airs" that had so puzzled the men of Boyle's day was determined: oxygen, nitrogen, hydrogen, methane and the composition of water and carbon dioxide came to be known. The chemical balance came into daily use. New elements were discovered and new inorganic compounds were made. An increasingly large number of organic compounds were being isolated as definite chemical individuals from a variety of vegetable products and from the tissues and secretions of man and animals. In this period falls the discovery and isolation of some very important products of animal metabolism, as urea (1773), uric acid (1776), allantoin (1800), cystine (1810), creatine (1835), glycerin (1779) and other chemical principles, the study of which was later to exert so great an influence on the development of synthetic chemistry. In this period also the pharmacist-chemists isolated quinine from the cinchona bark, that beneficient febrifuge (*Pulvis febrifugus orbis americani*) introduced into Europe from the new world nearly two centuries before; that gift of the gods, the juice of the poppy, was made to yield in crystalline form its analgesic morphine and its less valuable sister alkaloid, codeine (1803–1823). The seeds of the strychnos tree yielded up strychnine and brucine; hellebore and cevadilla seeds, veratrine; ipecacuanha, emetine; tobacco, nicotine; and a little later atropine was isolated from belladonna. A discovery of fundamental importance for chemistry, medicine and the arts was Faraday's isolation of benzene from gas distillation residues in 1825. Of his "bicarburet of hydrogen," by which name the new hydrocarbon was designated, Thorpe wrote a quarter of a century ago: "the work which has accumulated around this single substance during the 75 years which have elapsed since it has been known constitutes one of the most astonishing records of intellectual and industrial activity of which history has any record."

But the first quarter of the nineteenth century was a period when men did not solely occupy themselves with the isolation of elements and new compounds but, as in the quarter of a century that we have just lived through, minds of a high order also developed theoretical principles. Years after the enunciation of Boyle's Law and more or less coincidently with a host of brilliant discoveries of the very greatest importance in various departments of physics and in applied mathematics appeared Avogadro's law and Dalton's atomic theory. I need only recall to your minds the names of some of the greatest investigators in physics of this era, as Faraday, Ampère, "the Napoleon of electricity," Oersted, Ohm, and preceding them, Galvani, Volta and Coulomb among those who laid the foundations of electro-dynamics; of Thomas Young and Fresnel in the field of light, of the great Carnot and of Fourier in that of heat, of Gay-Lussac and Mariotte in the field of the gases, of Dulong and Petit, who showed that the atoms of elementary substances have the same capacity for heat. The important discovery that substances having an identical elementary composition may yet differ in their chemical or physical properties or both —isomerism—also falls in this period (1823), as also the enunciation by Grotthus (1818) of the fundamental principle underlying all chemical processes involving the absorption of light energy. It was indeed a remarkable period. Science and biology have been benefited as much or even more in consequence of these discoveries in physics of a century ago than by the chemical additions to knowledge that were coincidently made.

The formulation of such general statements capable of mathematical treatment is, as is known to all, the highest aim and the ultimate goal of the scientist's activity. We, who deal with the chemical and physical complexities of living organs, where the variables are not only very numerous but also where the dependence of each of these variables on one or more of the others must be taken into account, can but regard the full attainment of these highest aims of biological science as something that lies in the far future.

It should be stated, however, that many special topics in the broad field of plant and animal physiology are already capable of quantitative treatment, and many of my colleagues will feel that I have understated our case. They will call to mind investigations in relation to vision, muscle contraction, the nature of the nerve impulses, the neutrality mechanism, respiration and metabolism, to cite only a few examples from physiology to which quantitative methods are applicable.

But let us trace still further the relationship between chemistry, biology and medicine. The character of this relationship is now becoming reversed. No longer are the devotees of the biological and medical sciences foster-parents or foster-brothers of yours as in the old days. It is we who are now dependent in a large part of our work upon you and your fellow scientists, the physicists.

The reason for this change in relationship is not far to seek. It lies primarily, as stated above, in the fact that your science has devised many more diverse and accurate methods of measurement.

The Era of Chemical Synthesis

Hardly had the first quarter of the nineteenth century passed when new developments arose, more especially in organic chemistry, that were destined to push forward in an immeasurable degree not only man's ultimate conquest of nature but also his ability to control or conquer disease and to prolong life, and hence, in so far as this may contribute to that end, to increase the sum of human happiness. The new era that has brought priceless gifts to mankind is the era of chemical synthesis. In conformity with my plan of emphasizing the importance, for the biological sciences and medicine, of only the great achievements of your science in this era I must limit myself to a brief survey of the discoveries of a few among the great men whose work happens to be of especial significance for these sciences. Let me begin with Liebig, whose contacts with medicine came through pharmacy, to which profession he was apprenticed in his early youth, and who later continued his chemical studies in Paris under Gay-Lussac. In his "Organic Chemistry in its Applications to Physiology and Pathology," published in 1842, after stating that "the great physicians who lived toward the end of the seventeenth century were the founders of chemistry and the only philosophers acquainted with it," and deploring the fact that "modern chemistry, with all its discoveries, has performed but slender services for physiology and pathology," he gives expression to his belief that:

> The most beautiful and elevated problem for the human intellect, the discovery of the laws of vitality, can not be resolved—nay, can not even be imagined—without an accurate knowledge of chemical forces: of those forces which do not act at sensible distances; which are manifested in the same way as those ultimate causes by which the vital phenomena are determined; and which are invariably found active whenever dissimilar substances come into contact. . . . Before the time of Lavoisier, Scheele and Priestley, chemistry was not more closely related to physics than she is now to physiology. At the present day chemistry is so fused, as it were, into physics that it would be a difficult matter to draw the line between them distinctly. The connection between chemistry and physiology is the same and in another century it will be found impossible to separate them.

After this confession of faith by Liebig we can no longer wonder that this great chemist concerned himself during many fruitful years with numberless questions touching the life processes of plants and animals; that he should be remembered to-day not only for his lasting achievements in organic and in technical chemistry, for having been a great teacher and inspirer of young men, but also as the founder of agricultural chemistry and as the most notable among the modern founders of biological chemistry since Lavoisier.

You all know that to the beautiful friendship which existed between him and the great Wöhler, unique in the history of science, and to the fortunate collaboration of the two in research, we owe some of the very greatest contributions ever made to the subjects now under consideration. Friedrich Wöhler studied medicine as a young man, taking his degree in medicine and surgery at Heidelberg in September, 1823. While a lad at the Gymnasium, he devoted himself passionately to chemical experimentation and to the collection and study of mineralogical specimens, much to the neglect of his school subjects. At Heidelberg he came into close contact with the chemist Gmelin and with the physiologist Tiedemann. Before he had taken his degree the young Wöhler had already completed four investigations dealing with selenium and with cyanic compounds and the year (1824) after his graduation he published a very comprehensive study, originally intended for a graduation thesis, of the excretion in the urine of a very large number of substances, including iodine, carbonates of the alkalis, saltpeter and other inorganic compounds; numerous organic acids, including benzoic acid, substances that color the urine, as indigo and rhubarb, and such as impart an odor to this secretion, as turpentine and asparagus. This paper, entitled "Experiments on the Passage of Substances into the Urine," was awarded a prize by the medical faculty of Heidelberg, and can be read to-day with profit by physiologists and pharmacologists, not alone for its numerous references to the work of other investigators of that time, but also because of the wonderful acumen with which the youthful investigator discusses the true function of the kidneys and the cause of the acidity of the urine. He sums up his deductions in regard to the kidney in the following passage:

> The kidneys are organs that serve the purpose of secreting a fluid composed in part of such substances as

pass in the unassimilated condition into the blood, being incapable of serving as replacers of bodily constituents, and in part of such as are produced during digestion and during the interchanges of material in the animal body (intermediary metabolism) or which are finally thrown off as being of no further use in these interchanges; they are therefore organs that serve to maintain the composition of the blood in a state necessary to the maintenance of life, without themselves producing any new substance whatever.

Pharmacologists of a later day were to show that Wöhler's "physiological deductions" needed to be modified in that the kidneys have a definite though limited power of synthesis and physiologists have also proved that, in addition to the kidneys, the respiratory function serves also to maintain the composition of the blood and tissue juices in the chemical equilibrium necessary to life.

Fortunately for both medicine and chemistry, Liebig and Wöhler in 1837 elected to attack the problem of the chemical constitution of that important metabolite, uric acid, first isolated by Scheele from urinary calculi in 1776, which up to that time had been of interest only to medical investigators and practitioners because of its connection with gout. As A. W. Hofmann so aptly remarks, this constituent of our body has shown itself to be a very protean among organic chemicals.

The results obtained by these two great investigators in their study of this acid and of the more than sixteen entirely new derivatives which they were able to prepare from it, as also of the many previously known substances that were encountered by them during their oxidation and reduction experiments in this field, have been described in detail by A. W. Hofmann and have also been outlined in a fascinating manner by T. E. Thorpe in his essays on historical chemistry. These memorable researches on uric acid excited the highest admiration of the chemists of the day, and I need not comment further on their significance for organic chemistry or for the future development of chemical physiology.

I need not comment either at length on the great consequences for organic chemistry and for medicine that flowed from the collaboration of the pair in their researches on the nature of the oil of bitter almonds, suggested by Wöhler to Liebig in 1832 as a suitable subject for a joint research. It must have been something akin to inspiration, says Thorpe, that led Wöhler to suggest the subject. I have often wondered whether the germ of the idea could not be traced to Wöhler's wide knowledge of medicinal substances. Oil of bitter almonds had long been in use as a domestic remedy, and Wöhler, who, in addition to his professorship at Göttingen, also held the post of supervisor of pharmacies for the Kingdom of Hanover, must have been well aware of the medicinal properties of the oil. The discovery of the compound radical benzoyl (and of benzoyl chloride) and the proof that numerous correlated bodies could be grouped around it were epoch-making in their far-reaching consequences and will always remain, historians of science are agreed, one of the greatest achievements in organic chemistry.

Wöhler's discovery in 1842, made also independently by Alexander Ure, of Edinburgh, in 1841, that ingested benzoic acid is paired in the animal organism with glycocoll, or amino-acetic acid, and excreted as hippuric acid, which, from a purely chemical point of view, may be regarded as only a minor addition to the "benzoyl" edifice, became nevertheless of the greatest significance for physiology and pharmacology as constituting the first demonstration that the animal organism has the power to combine chemically dissimilar substances into new compounds—a capacity for synthesis that up to that time was believed to be confined solely to plants. This discovery naturally led to wider views in respect to the nature of intermediary metabolic processes. Since 1842, biochemists and pharmacologists have discovered innumerable other instances of the very considerable synthetic power with which animal tissues are endowed and the conception no longer excites wonder by its novelty.

The significance of Wöhler's discovery in 1828 of the artificial formation of urea by the molecular transformation of ammonium cyanate is known to every freshman in our schools of chemistry and medicine. This discovery, the significance of which was fully realized by the young Wöhler, effected a revolution in the ideas of men and showed that the organic substances present in bodies of animals and in plants can not be the products of a mysterious vital force but are subject to the same laws as those that are encountered by the chemist in his laboratory while occupying himself with bodies of purely inorganic origin.

Of the chemists of the period under consideration who were intensely interested in the chemical phenomena presented by plants and animals, I can refer here only to the great French chemist, Jean Baptiste André Dumas, the contemporary of Wöhler and Liebig. At the age of eighteen, the young pharmacist detected the presence of the newly discovered iodine in burnt sponge, a substance employed at the time in treatment of goiter, and later worked in conjunction with the physiologist Prévost on the active principle of digitalis, on the transfusion of blood, on the seat of formation of urea in the body, on the chemical changes accompanying the embryonic development of

the chick and many other chemico-physiological questions. Naturally, even a man of Dumas's ability could not, at that time, make any significant advance in our knowledge in his too brief excursions into these difficult fields. He and Prévost were, however, the first, as far as I am aware, to demonstrate by experiments on nephrectomized animals that urea is not formed in our kidneys but elsewhere in the system, as they were still able to detect it in the blood of the nephrectomized animals.

In his later years, long after he had won his place among the great chemists of his time, Dumas returned, says Thorpe, to many of the chemico-physiological problems with which, in association with Prévost, he had begun his career as an investigator. In this later period fall his studies with Boussaingault on the formation of fat in the animal body and his own studies on the origin of bees'-wax. He proved that bees, even when fed exclusively on sugar, still retained the power of producing wax, contrary to the opinion of his predecessors, who believed that the bee secretes the wax while extracting the honey from flowers and that there is no necessary connection between the two processes. The nature of alcoholic fermentation and the treatment of the silkworm disease induced by *Phylloxera vastatrix* were among the later interests in the life of this gifted and many-sided man.

Having unfortunately little leisure for the pursuit of historical studies, I am fully conscious of the fact that I have given you a very sketchy outline of the points of contact between chemistry and medicine from Paracelsus to the time of Liebig, Wöhler and Dumas. The problem of animal respiration we had left in the state in which it was formulated by Lavoisier. But even after Spallanzani and others had shown early in the nineteenth century that consumption of oxygen takes place in the tissues themselves rather than in the blood, a true solution of the problem could not be arrived at without quantitative data in regard to the oxygen and carbon dioxide content of both arterial and venous blood. Here a non-medical investigator, Gustav Magnus, professor of physics at Berlin, came to the rescue of physiology in 1837. By means of the mercurial air pump he was able to liberate oxygen and carbon dioxide from both arterial and venous bloods and to show that the percentage of oxygen is greater in arterial blood while that of carbon dioxide is greater in venous blood. These determinations by Magnus were afterwards amplified by the physiologists Pflueger, Ludwig and his pupils, among whom was Lothar Meyer, later to win distinction in pure chemistry, and their work, in conjunction with the labors of many other investigators during the last half of the nineteenth century, has given us a theory of both internal and external respiration which the science of our day has only been able to expand but not to overthrow. The historian Fielding H. Garrison pithily remarks that "the development of the physiology of respiration from Borelli to Magnus was almost exclusively the work of three mathematicians, two physicists and five chemists."

In respect to the further developments in regard to both internal and external respiration, I can not do better than transcribe the concise description by one of your own guild, Professor W. Mansfield Clark:

> In all science there are few developments as beautiful as those which have given us the precise knowledge of the blood equilibria. There have been found: a quantitative relation between the iron of the blood pigment and the oxygen combining capacity; quantitative data for the equilibria between partial oxygen tensions and degree of oxygen saturation of haemoglobin; preliminary data on the Donnan equilibrium between the oxygen-carrying blood pigment, trapped within the semipermeable membrane of the red cell, and the plasma; exact relations for the bicarbonate equilibria of the plasma and the acid-base properties of the oxygen carrier; the mechanisms for the maintenance of constant hydrogen-ion concentration of the blood and the control of lung ventilation by the activation of a nerve center called the respiratory center. Of this Haldane says, "A rise of 0.2 per cent. or 1.5 mm. in the CO_2 pressure of the alveolar air and arterial blood causes an increase of about 100 per cent. in the resting alveolar ventilation. The outstanding delicacy of the regulation of blood reaction is thus evident. No existing physical or chemical method of discriminating differences in reaction approaches in delicacy the physiological reaction."

The prophecy of Liebig has been realized. In our day chemistry and physics have become fused into the very structure of the biological and medical sciences. But despite the fact that chemists during the past seventy-five years have necessarily concerned themselves largely with the development of their science along inorganic, synthetic, physicochemical, quantitative and, in recent years, more and more along electrochemical and mathematical lines, they have nevertheless, as in earlier times, continued to take an interest in the chemistry of life processes. It would too greatly lengthen this paper to give even a brief outline of the hundreds of contributions that have been made by the chemists of all countries to biochemistry since 1860 or thereabouts.

An outstanding example or two of the contributions of chemists to biology from that time to ours must suffice. And here there naturally comes first to mind the name of Emil Fischer, one of the very greatest experimental chemists of all time, whose outstanding contributions toward the solution of the

most difficult and important among biochemical problems will always be looked upon with veneration by those who are conversant with the researches of this genius and have a first-hand knowledge of these difficult subjects. His researches on the chemical structure of the sugars and on the very specific ferments that liberate them from their derivatives, and on the structure of the proteins and their primary and secondary cleavage products effected a revolution in our chemical concepts of these products of vital activity and opened up new vistas in regard to biochemical processes. An analysis and a description of his monumental discoveries in regard to the members of the purine group and their allies, as found in both animals and plants, would carry us back to Scheele's discovery of uric acid in urinary calculi and then to a consideration of the earlier discoveries of his predecessors, Wöhler, Liebig, Fourcroy, Grimaux, Baeyer, Strecker, Horbaczewski and others. Suffice it to say that the contributions of Emil Fischer surpass in their ultimate significance for chemical physiology those ever made by any other man in the entire history of biological and medical science.

By substitution, degradation and especially synthesis, he established the genetic relationship between uric acid, xanthine and hypoxanthine and their multitudinous substitution products and showed that they may all be considered as derived from a substance $C_5H_4N_4$, for which he proposed the name purine (from *purum* and *uricum*) and which, although purely hypothetical at the time, he afterwards succeeded in synthesizing. In the field of the sugars, with the aid of phenylhydrazine, which he himself had discovered at the very outset of his scientific career (1875), he was able to isolate in pure form not only the few then known natural monosaccharides, but a host of others whose existence he predicted from the van't Hoff theory of the asymmetric carbon atom and which he synthesized by the skillful application of a number of general reactions, and in this way established the structures and configurational relationships of this very important group of substances. He also studied in detail and clarified the chemistry of the glucosides, their structure and spatial configurations and especially their behavior towards enzymes. The ester method for the separation of amino acids which he devised enabled him to determine much more nearly quantitatively than had hitherto been possible the composition of the complex mixtures resulting from the hydrolysis of proteins, and led to the discovery of several still unknown amino acids in such mixtures. These amino acids he succeeded in condensing with each other in amide-like union to substances which he called peptides and which, as the number of the amino acid residues of which they were made up was increased, approached closer and closer in physical and chemical properties to the peptones obtained from natural products. Similarly, he found that the tannins are glucosides of ester-like combinations, "depsides" (from δεψειν, to tan), of phenolcarboxylic acids joined to each other through a phenolic hydroxyl group of the one and the carboxyl group of the other. As in his protein work, after having determined the nature of the component units of the natural products, he synthesized numerous compounds more and more resembling these natural products in their chemical reactions and physical properties.

As I am noting here more particularly the contributions of certain leaders among so-called pure chemists toward the elucidation of the chemical occurrences in living things, rather than those of biochemists, pharmacologists and physiologists, significant as these have been, it is only natural that I should refer to the work of Willstätter, A. v. Baeyer's distinguished pupil. You are all familiar with the brilliant researches of this master and his pupils on the chemical nature of chlorophyll and with their success in isolating in crystalline form the chemical individuals that had originally been grouped under that comprehensive term. It has been said that if it can be assumed that one thing is of more importance than others, then chlorophyll is undoubtedly the most important and the most indispensable of all things. The epigram contains a larger element of truth than is usually inherent in pithy sayings. Certainly the chloroplast of the green leaf, one of the most wonderful of all chemical laboratories, activated, as it is, by the sun's radiations, taken into consideration with the chemical activities of the other plant physiological mechanisms, offers problems that challenge the highest skill of the chemist and bio-physicist. And here in this broad field of photo-synthesis we find pure chemists, plant chemists and physicists combining forces in our day as never before, in the solution of problems of the greatest significance, both from a theoretical and a practical point of view.

Willstätter and his collaborators, building on the foundations laid by earlier workers, Hoppe-Seyler, Gautier and others in the eighties of the last century, v. Nencki, Küster and others since 1900, have finally given us a clear picture of the chemical relationship that exists between haemoglobin, the respiratory pigment of our blood, and the assimilatory chlorophyll pigments of plants. The relationship is of philosophical as well as bio-chemical interest. Both classes of pigments have essentially a comparable structure, the

basic complex of each, called aetioporphyrin by Willstätter, being a compound consisting of four substituted pyrrole nuclei united through two carbon atoms. The blood pigment contains iron and the plant pigment magnesium in combination, partly through normal and partly through secondary valences, with the nitrogen atoms of the pyrrole groups in the aetioporphyrin complex. On degradation the two pigments yield the red, metal-free porphyrins which are broken down by oxidation into the anhydride or imide of haematinic acid and this by loss of carbon dioxide gives methylethylmaleinimide.

A second field of the greatest importance to both plant and animal physiology which has been greatly advanced by Willstätter's researches is that of the enzymes or organic catalysts. These products of vital activity, in contrast to inorganic catalysts, such as the acids, the various elements and metallic compounds employed in our laboratories, are so highly specific in their action that a particular biose, as milk sugar, cane or malt sugar, for example, is only capable of being hydrolyzed by a special enzyme, the only one, indeed, that is capable of effecting its hydrolysis. By devising new and ingenious modifications of a method long employed in biochemistry, that of adsorption, this investigator has been able to separate from their mixtures, and to obtain in a high degree of purity, many enzymes and to differentiate, for example, two such closely related sugar-splitting enzymes as saccharase and maltase. The skilful employment of metal hydroxide gels, more particularly the various structural modifications of aluminium hydroxide, enabled Willstätter to effect these extraordinary separations of enzymes from the various impurities and the activating and inhibiting substances that are always associated with them in the naturally occurring mixtures with which we have to deal. The new methods may truly be described as selective adsorption methods, as has been done by Willstätter, and it is interesting to note, as he points out, that this selective adsorption is determined, not by the degree of dispersion or other physical state of the adsorbing compound, but rather by its chemical structure.

The researches of a century have shown how very numerous are the specifically acting enzymes that are present wherever protoplasm functions, whether in single-celled organisms or in the more intricate structures of the higher plants and animals, and how varied are the chemical operations whose entire course, that is to say, whose rates of reaction and elaborated products are determined by these unique agents of vital activity. Admittedly, the further elucidation by chemists of both the dynamics and the organic structural problems here presented will yield results of the greatest significance both for chemic science and for the better comprehension of the li processes. For your consideration as chemists, I sh conclude my remarks on this aspect of biochemist by the citation of a passage from a recent address Willstätter on "New Methods in Enzyme Research

Of the characteristics of enzymes only the structur chemical and probably also the stereochemical specifici are uninfluenced and constant. The sugar-splitting e zymes show the strictest specificity in both respects, regards chemical constitution and arrangement in spac the fat-splitting enzymes have a wider range of activi on structurally different, ester-like substrates. But th appear to be more finely differentiated in their stere chemical specificity. If we compare the lipases of t pancreas, the liver, the stomach and the fungi as to the action on the same racemic substrate we find all differe from each other in their selective action, preferring, no in the one case, now in the other, the d- or the l-form, only we use a sufficiently large number of the racem esters, as, for example, of the mandelic acid group. Th configurational specificity can so far be considered as enzyme constant. Thus far there has been observed case where the influence of foreign bodies determines t direction of the rotation of the preferred compound.

Even a rapid survey of the many other fields which chemists and biologists have an interest in com mon would transcend the limits that time and a co sideration for your patience impose upon me. The remain, for example, the problems that arise in co nection with the nature of the oxidation and reductio processes that are carried out in our bodies at 37.5 C —problems that stand in the closest theoretical rel tionship to the efforts of your fellow chemists to ex plain the true mechanism of even the simplest of ox dations, as that of carbon monoxide to carbon dioxid My personal interest in this most fundamental of bio chemical problems stands in inverse ratio to my abilit to treat it adequately, even were there time at m disposal to do so. Fortunately I can refer you to th concise and elegant outline of this subject that wa given us in Baltimore two years ago by Professo Stieglitz in his Dohme lectures. This field, I am happy to say, is being tilled intensively by the younge physical, organic and biochemists of the day. Th earlier experimental observations of pharmacologist and physiologists in respect to the influence of change in the *milieu* on the oxidative capacity of cel are now receiving an interpretation more in accor with our newer conceptions and more capable o mathematical treatment. Thus, W. Mansfield Clark who has distinguished himself in this field, points ou in one of his recent papers how intimately related ar the oxidation-reduction systems and acid-base system of the animal organism, and adds:

his has long been suspected to be a matter of pro-
d importance in physiology, but it is believed that
(his) is the first systematic presentation among the
erous theoretical possibilities among the interrelated
-base and oxidation-reduction equilibrium states.

have also no time to comment on the reasons that
nce the pharmacologist to follow your investiga-
s with an absorbing interest and with keen enthu-
m. Some of these reasons are found in the bio-
mical problems outlined above, the essential parts
which are woven into the very texture of his
ught, if I may say so. But quite aside from these
e fundamental problems, there exists also a com-
nity of interests between us concerning the invalu-
e remedies with which chemists, working often in
e cooperation with the pharmacologists, are en-
hing our *materia medica*. Occasionally, alas, in
ir cooperation in this field, both parties have fallen
o the very human error of exaggerating the practi-
importance of their discoveries and researches—
ich latter, indeed, are often too solely and too
nsiently utilitarian in purpose and in character to
ound to the credit of either party to the trans-
ion.

In regard to the influence that our American prede-
sors and our own contemporaries in this country
e had in shaping the future course of the biologi-
and medical sciences I need not speak at length.
ur influence, direct and indirect, on these sciences
be traced in the pages of the admirable historical
iew of your activities during the past half century
blished in the Golden Jubilee Number of *The*
rnal of the American Chemical Society, though
dently the biochemical implications of this half-
tury's work could not always be brought out by
writers of that volume. As never before in our
tory, our younger biological and medical investi-
ors are utilizing in their investigations the methods
d principles of the various divisions of your science.
study of the various chemical, biochemical, bio-
ical, pharmacological, physiological and experi-
ntal medical journals of the country will furnish
nclusive evidence that our countrymen are making
e progress in the broad fields covered by these
rnals.

Physical Chemistry and Biology

I come now to a consideration of some special
ints of contact between the physical chemist and
biologist, quite apart from the numerous refer-
ces that have already been made to such contacts
earlier passages of this lecture. These contacts are
nditioned by the composition and structure of the
ing substance—protoplasm—and the multifarious
its—the cells of plants and animals—to which the
protoplasmic structures are confined. The cell doctrine, far-reaching in its influence upon medicine and biology, as finally formulated by Dutrochet, Schwann and Scheiden before the middle of the last century, is to be counted among the very greatest discoveries of that century, comparable in its consequences for biology to those that followed the acceptance of the atomic and molecular hypothesis in chemistry.

The mysteries of life lie concealed in these units, individually of microscopic size only, and specialized in structure and function in the multicellular plants and animals. Naturally, I can not here comment on the reasons that necessitate a minimum external surface area for a cell, nor can I consider the influence of cells upon one another, nor the inadequacy of the cell theory to cover satisfactorily all the facts of development, as is claimed by a few biologists. The individual cell, wherever found, must be regarded as a congeries of minute, discrete chemical factories, standing in a possibly mobile spatial relationship to one another and working together in a beautifully harmonious manner. Surfaces, internal and external, and surface energies are of paramount importance in these individual units of life, as they are also when the units are aggregated in a manner to produce areas astonishingly large in dimension. The total internal surface of a given single cell, when the extensive colloidal interfaces, not to mention the limiting surfaces of the nuclei, nucleoli, chromosomes, plastids, zymogen granules, vacuoles or other microscopically determinable components, would, if computable, be found to be very large in comparison with that of its outer envelope. These internal surfaces, or boundaries between contiguous phases, are the seats of all manner of changes and operations, not merely all such as are broadly described as physico-chemical in character (electric charges, etc.), but I venture to assert that all those protoplasmic processes that are usually defined as purely chemical in character, that is to say, oxidations, reductions, syntheses, hydrolytic decompositions, etc., are likewise surface actions. In the living cell, then, we have a system, the *microphysical* or *ultramicrophysical structure* of which differentiates it entirely from the systems of our test tubes and enables the cell to carry on all of its manifold processes at 37.5° C., more or less, as the case may be.

The labile oriented molecular arrangement in space and time of the surfaces of discontinuity of the phases of the various heterogeneous systems of the living cell and the constant interaction of these surfaces with sources of free energy of the environment, may account for the continued differentiations, apparently purposeful and directed, that characterize living things, as compared with the trend of non-living things toward less complex states. It may well be

that an increase in our knowledge of molecular mechanisms in both fields will prove that the difference in behavior of living organisms and matter devoid of life is, in the last analysis, one of degree and not of kind.

I have said above that considerations of surface are of paramount importance in biology. Nature has found a means of producing very large surfaces by the aggregation of countless cells, as in leaves, root tendrils, capillaries and innumerable other structures. Krogh has calculated that if we suppose the total weight of a man's muscles to be 50 kilograms and his capillaries to number 2,000 per square millimeter of cross section, the total length of the capillaries of our muscles alone would be something like 100,000 kilometers, and their total surface 6,300 square meters. Our lungs, when collapsed, are small organs, but in them are found 725,000,000, more or less, of little pockets or alveoli where our thin-walled capillaries exchange carbon dioxide for oxygen. The total internal area of these lung terminals or alveoli is close to 100 square meters, enough for thirty suits of clothes, as Sir Arthur Shipley puts it in his valuable little book entitled "Life." The thin-walled capillaries of the lungs, one thousandth of a millimeter in wall thickness, make it possible for the slow process of diffusion to do the work necessary for the maintenance of life in less than the four seconds of each respiratory act. And so everywhere throughout the body we find these enormously extensive areas of cell surfaces—mechanisms for effective adsorption, secretion and excretion in the unit of time.

I can not close this outline of "contacts" without a few further words on the bearings of physical chemistry on physiology and medicine. Every scientist of our day has learned that our countryman, J. Willard Gibbs, a man of the highest genius, by his fundamental and profound researches first placed the theory of surface phenomena on a truly scientific basis and made it capable of statistical and thermodynamical treatment. Since his day our knowledge of the actual molecular structure of the surfaces of both simple and heterogeneous systems has been greatly extended by scientists in this and in foreign countries —in this country by Langmuir, Harkins and others. Now, for more than half a century, physiologists and pharmacologists have been impressed, by the nature of the problems they were facing, with the need of more accurate knowledge of the physicochemical and chemical occurrences at the interfaces and limiting membranes of living structures. Naturally, their problems are bound up with questions involving adsorption and surface tension, colloidal sols and gels, the influence of the ever-varying chemical state of cell membranes, catalysis and related actions. Pharmacologists have always been confronted by th physico-chemical difficulties encountered in their a tempts to analyze and understand the effects of drug including the powerfully acting hormones of o body, on both unicellular organisms and on the mo complex structures of the animal body. My collabora tors and I, to give but one example, have encounter such difficulties in our attempts to explain the i creased susceptibility of the central nervous system o frogs to certain dyestuffs (ordinarily harmless) wh administered subsequently to certain, otherwise trivia injuries which so greatly increase the permeability o the capillaries and the adsorptive power of the cel of the brain and spinal cord that the ordinarily harm less dyestuff now reaches such a concentration in thes cells (as can be shown by color tests) that violen strychnine-like convulsions immediately follow.

Workers in the medical sciences, as in biology, ar bound to profit greatly, if not at present, then later by the newer revelations in regard to the molecula structure of surfaces, more particularly those o micro-heterogeneous systems. They will agree wit Professor Donnan when he gives expression to hi conviction that "the newly recognized 'two-dimen sional' molecular world . . . and the new knowledg of the structure of this 'surface world' presents phe nomena of molecular orientation of the highest im portance for the understanding of great regions o natural phenomena." Even though physical chemist are at present in disagreement in respect to man points in connection with this "two-dimensional molecular world, the biologist must greet with enthu siasm every new and undoubted fact here discovere and the future theoretical developments in relation t it, even though he may only imperfectly comprehen the latter.

I realize fully that it is not within my competenc to speak authoritatively in regard to the contacts be tween physical chemistry and vital occurrences, but I can not forbear citing, as a conclusion to my remark on this subject, a heartening passage from Professo Donnan's address "On the influence of J. Willar Gibbs on the science of physical chemistry":

> In physiology the power and value of thermodynamica methods have been fully recognized only in comparatively recent times. Perhaps after another century of researc in this science there may come another Willard Gibbs who will discover the fundamental equations of the living cell, where the unseen of the past seems to reach out and grip the future. But for that we shall require something more than linear differential equations.

The biologist, having in mind the ambitious at tempts of the iatro-physicists and the iatro-mathe maticians of the seventeenth century, as Borelli and

hers, to reduce physiology to physics and "to orna-ent and enrich it by mathematical demonstrations," d while not unmindful of the great value inherent the contributions of these pioneers to haemody-mics and the mechanics of muscular movement, will el, nevertheless, that the physical chemists of our y, like their mathematical predecessors three cen-ries ago, do not always take into account the com-lexities encountered in this laudable purpose of re-cing life phenomena to fundamental equations. It not specialized mechanisms, as the muscle, the selec-ve permeability of membranes or certain definite emical and physico-chemical processes like those of e respiration, which are already capable of thermo-ynamical treatment, that offer difficulties to the alization of this laudable ambition, but the more eneral cytological problems of biology such as are countered in the study of cellular processes as a hole, of cell organization into highly differentiated tructures, and of development in general, together ith the difficult problems of heredity, that will tax e power of the Gibbses of the future. Or, consider e difficulties that will confront the mathematician f the future in his efforts to express the entire life rocesses and the reproductive powers of a single-elled organism only, as, say one of the paramoecia, the form of valid general equations. To the biolo-ist, it must appear that not one Gibbs but perhaps half dozen or more will be required and their genius ill be able to achieve results of value only after any more quantitatively determined biological facts hall be at their disposal than is now the case. The riter is an optimist in regard to the mental powers f the elect of our species, but he can not but feel hat a single century will hardly suffice for the reali-ation of these hopes, which biologists in general herish equally with physicists and chemists.

J. J. ABEL

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(To be concluded)

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

GRANTS IN AID OF RESEARCH, FOR 1928

THE allotment of American Association grants for 1928, in aid of research, will occur next December and all applications to be considered in that allotment must be in the Washington office by December 1. While the amounts of these grants are never large, being usually for sums less than five hundred dollars, yet this annual allotment constitutes an important part of the work of the Association. It is intended that the grants to individuals shall be specially useful in making possible the completion of important pieces of research already begun or that they shall be the means of supplying special apparatus or facilities, in cases where adequate funds can not be secured elsewhere. They are generally announced in January and the funds become immediately available. A grant may be disbursed in a single sum or in suitable installments according to the wishes of the grantee. All undisbursed grants or undisbursed portions of grants revert to the treasury on October 1 of each year, unless special arrangements have been previously made with the permanent secretary's office to have them made available for the next fiscal year. It will be remembered that the official year of the association extends from October 1 to the following September 30.

It is specially important that members of the association should be alert to the possibilities of these small grants and that the older members should give advice and suggestions to the younger members in this connection when occasion arises, to the end that the grants may be allotted to persons who will make the most of them and for projects that are of outstanding and pressing importance. Applications for grants may be made at any time, but no allotments are made excepting at the time of the annual meeting of the association. A special form of blank is now provided for applications. Copies of the blank are to be had from the permanent secretary's office. Each application should be supported by letters from at least two persons who are acquainted with both the applicant and the research project for which a grant is needed.

All applications for grants are referred to the Committee on Grants for Research, which makes allotments in December of each year. At the annual meeting the council makes an appropriation for grants allotted by the Committee on Grants. Each applicant receives a notice in January, informing him whether or not his application has been favorably acted upon. The permanent secretary acts as secretary of the Committee on Grants, but he is not a member of the committee and has no vote. The membership of the Committee on Grants for 1927 is as follows: Dr. Aleš Hrdlička (for Psychology, Anthropology, Education, Economics), *chairman*; U. S. National Museum, Washington, D. C. Dr. B. M. Davis (for Botany); University of Michigan, Ann Arbor, Mich. Dr. Joseph Erlanger (for Physiology); Washington University School of Medicine, St. Louis, Mo. Dr. Nevin M. Fenneman (for Geology); University of Cincinnati, Cincinnati, Ohio. Dr. L. G. Hoxton (for Physics); University of Virginia, University, Va. Dr. Vernon Kellogg (for Zoology); National Research Council, Washington, D. C. Dr. W. Lash Miller (for Chemistry); University of Toronto, Toronto, Canada.

Dr. Oswald Veblen (for Mathematics); Princeton University, Princeton, N. J.

Each person receiving a grant for any year is expected to send to the permanent secretary's office a report on the grant project, this report to be in hand before December 1. The report shows what has been done during the year. If the project has been completed the report may be final, otherwise a later report should be sent in. A progress report should be sent each October or November until the final report is rendered. In these reports grantees are expected to give references, with full citations, to any publications they have made on the grant project and reprints or copies of such publications should accompany the reports. It is also expected that, in the publication of results partly or wholly secured by reason of a grant from the American Association, shall be included due acknowledgment of that aid. A suitable acknowledgment may have such form as this: "Financial aid for the work here reported was received from the American Association for the Advancement of Science in the form of a grant for the year 1927." Apparatus purchased or constructed with funds from a grant was formerly held to be the property of the association, but it is now to be given by the grantee to his institution or laboratory, or is to be otherwise disposed of by him so as to be of further use in scientific research. The final report on a grant should show what disposal has been made of such apparatus. Any unused portion of a grant should be returned to the association.

BURTON E. LIVINGSTON,
Permanent Secretary

ALBERT WILLIAM SMITH

ALBERT WILLIAM SMITH was born in Newark, Ohio, on October 4, 1862, and died in Cleveland on March 4, 1927. He attended the school of pharmacy of the University of Michigan, from 1883 to 1885, graduated from Case School of Applied Sciences in 1887, and received his doctor's degree in Zurich in 1891. Even before his absence in Europe he was a member of the instruction staff in Case School, and he resumed his connection with the faculty upon his return in 1891. His life's work has therefore been very especially associated with this community. In 1897 he became professor of metallurgy, but upon Professor Mabery's retirement in 1911 he returned to the department of chemistry as professor of chemical engineering. In these years he has guided many generations of students into careers of usefulness, and each graduate carried out with him a special measure of regard and affection.

His time and experience he readily placed at the service of others. He served on the commission which studied the problem of Cleveland's water supply and recommended the filtration system. In the world war he was in the Chemical Warfare Service under the Bureau of Mines. He has for many years been consulting engineer and director of the Dow Chemical Company. He belonged to and took an active interest in the proceedings of the American Chemical Society, the American Institute of Chemical Engineers and the American Institute of Mining and Metallurgical Engineers. He was a member also of the American Association for the Advancement of Science.

In the Cleveland Section of the American Chemical Society and its parent organization, the Cleveland Chemical Society, he played a prominent part. Always valuable in its councils and its activities, he was three times its chairman and has for a long time represented it as councilor in the national organization.

To those who knew Professor Smith well and came within the sphere of his personal influence, there will always remain outstanding an impression of charm which graced and enhanced the value of his academic and scientific achievements. His character was so gentle, so kindly, yet so strong withal, that his influence was doubly effective and the circle of his admirers included all with whom he dealt. For his intimate contemporaries the void left by his loss will never be filled. It is pleasant to realize that the kindness and consideration which he measured out so generously to others found a rich return in the happiness of his family life and in the delightful relations which existed between him and his friends and associates.

H. G.

SCIENTIFIC EVENTS

RESEARCH FELLOWS OF THE LONDON ZOOLOGICAL SOCIETY

THE Zoological Society has lost both its anatomical and its aquarium research fellows, and the posts will be filled before the end of the year. We learn from the London *Times* that on the death of Dr. Sonntag in 1925, the council decided to transform the post into a research fellowship, tenable for a limited number of years, in the hope of securing ambitious young anatomists who would desire to devote themselves for two or three years to research on the rich material for comparative anatomy available in the Prosectorium, before passing to professional work at a medical school or university. It was arranged, moreover, to allow the anatomical fellow to combine his work at the Zoological Gardens with a certain amount of teaching at a London medical school, in order that he

might keep in touch with professors and students. Dr. John Beattie, a graduate in honors of the University of Belfast, was appointed from a number of candidates as the first anatomical fellow and was attached to University College as well as to the Gardens. During his tenure, which began with 1926, he has published a number of papers on vertebrate anatomy, and has now been appointed assistant professor of human anatomy in the University of Toronto.

The Aquarium Research Fellowship was instituted the end of 1924 to give na opportunity for such investigations into the conditions of aquatic life as could be conducted in the aquarium, where a laboratory and research tanks had been provided. It was decided that the first fellow should devote himself specially to the chemical and physical conditions in the aquarium plant, so as to lay a firm foundation for biological inquiries. The first fellow, Dr. F. P. Stowell, was a graduate in honors in chemistry of the University of Liverpool and began his work in the Gardens in 1925. He also has published a number of papers of great value not only to the management of the aquarium, but as additions to scientific knowledge. His tenure of the fellowship would have ceased at the end of this year, but he has received an appointment as research chemist to a large manufactory and left at the beginning of this month to assume his new work. It is intended that his successor in the fellowship should take up a biological line of investigation.

THE VOLTA MEMORIAL FELLOWSHIP

THE Italy America Society announces that a fund of $25,000, the income from which will be applied each year to post-graduate work in an American university of an electrical engineer from Italy, has been established by individuals, associations and corporations in this country who are interested in electrical development. The fund has been raised to mark the one hundredth anniversary of the death of Alessandro Volta, inaugurator of a new era in electricity.

Volta's anniversary has been marked this year with a special program in connection with the International Exhibition at Lake Como, Italy, where announcement of the formation of the memorial fund in the United States was received with much enthusiasm. The student who will come to the United States will be selected competitively by the Associazione Elettrotecnia Italiana, which corresponds to the American Institute of Electrical Engineers. In the United States the administration of the fellowship is in the hands of the Italy America Society.

Maurice A. Oudin, vice-president of the International General Electric Company and chairman of the memorial committee, has outlined the purposes of the fellowship as follows:

> The year 1927 marks the one hundredth anniversary of the death of Alessandro Volta, and we, a committee representing some of those interests which owe a debt to the discoveries of Volta, have established this annual fellowship to enable an Italian electrical engineer, a graduate from one of the leading polytechnic schools of Italy, to spend one year in the United States in study and research. With the advice and suggestions of competent persons, the fellow will devote one scholastic year to attending one of our schools of engineering, and will be given an opportunity to visit our principal plants. He will return to Italy enriched by his American experience and better able to be useful in the electrical development of the country which gave birth to Volta.

COMMITTEE ON THE COST OF MEDICAL CARE

A BULLETIN has been issued by the Conference on Economic Factors affecting the Organization of Medicine giving information regarding the purposes of its new committee—the committee on the cost of medical care which was organized last May in Washington.

The committee, which is to serve five years, has been assigned the following functions by the parent organization.

(1) To conduct an analysis of the problem of medical organization, particularly of its economic factors.

(2) To plan a series of researches on the basis of the proposed analysis, utilizing, as the committee may see fit, the outline of studies prepared by the Committee of Five appointed at a preliminary conference held in Washington April 1, 1926. These studies are to be assigned to various interested agencies and individuals, and they will be subsidized only when they can not be properly undertaken without financial aid.

(3) To conduct a limited number of studies when it becomes evident that they can not be handled adequately by any existing agency.

(4) To arouse the interest of professional groups and the public in the facts regarding medical service as they become available, particularly in the results of the committee's studies. The committee will promote discussion by medical, public health and economic agencies, arrange or encourage addresses before organizations of the "consuming public" and conduct various kinds of conferences. The publication of articles in professional and popular journals will be provided, and reports on the committee's researches be issued.

An executive committee of the committee on the cost of medical care has been appointed with power to increase its number to seven or nine members, the chairman being Professor C.-E. A. Winslow. J. Shelton Horsley.

An annual budget of $40,000 has been adopted.

Of this amount a grant of $10,000 (announced at the time of the conference, May 17) has been made by the Twentieth Century Fund, subject to conditions which it is hoped may be met. Since the conference, a grant of $15,000 has been received from the Milbank Memorial Fund.

TRIBUTE TO PROFESSOR HENRY FAIRFIELD OSBORN

Professor Henry Fairfield Osborn, president of the American Museum of Natural History and research professor of zoology in Columbia University, was the guest of honor at a reception in the Hall of Birds at the museum on September 29. The celebration was in honor of Dr. Osborn's seventieth birthday, which occurred on August 8.

As Professor Osborn was not to be in New York on that day, a subcommittee waited upon him at Garrison on July 28 to make the presentation of a Queen Anne cup and birthday greetings. The cup was inscribed: "To Henry Fairfield Osborn, master builder, upon the occasion of his seventieth birthday, August 8, 1927, from his friends." The greetings were signed by more than five hundred of Professor Osborn's colleagues and friends from all over the world, the signatures being inscribed on individual cards of vellum which were then assembled and mounted in an illuminated book.

A total of $8,040.71 was raised for the gifts. About $5,000 remained after their purchase, and this sum will be used for a Henry Fairfield Osborn seventieth birthday research fund in paleontology.

The following is the text of the congratulatory address:

On your seventieth birthday your colleagues and friends join to salute you, to congratulate you and to express their delight in finding you radiant in health and spirit, joyously carrying on your life work.

We desire to thank you most heartily for your leadership in many fields. Drawing around you in the American Museum of Natural History a staff of explorers and coworkers who are animated by your spirit and who gladly enroll under your banner, you have penetrated to the uttermost parts of the earth and have brought its natural history treasures to the museum. To your unceasing labors, as curator of paleontology and as president, we owe the series of unique exhibition halls at the museum, where countless visitors pass before an impressive panorama of extinct life. Thanks to your sympathetic understanding, the school-children of New York and their teachers enjoy all the educational and emancipative opportunities of the Museum's School Service. And in the near future the museum will also display still other imposing evidences of your constructive genius when the Roosevelt Memorial Hall and the Akeley African Hall take their places in the assemblage of buildings devoted to science and education.

We desire also to express our admiration of the creative, tireless spirit which, during a life crowded with administrative work, has produced a series of publications, covering many hundreds of titles and ranging from brief articles in *Natural History* to the great monographs on the titanotheres and the proboscideans, now in press.

We congratulate you upon the many distinguished honors that the highest scientific tribunals of the world have awarded to you in recognition of your services to science. We join the great company of your readers in acknowledging our indebtedness for such classic works as "From the Greeks to Darwin," "The Origin and Evolution of Life," "The Age of Mammals" and "Men of the Old Stone Age."

Princeton University will not forget your services when in 1877 as co-leader with your life-long friend Professor W. B. Scott, you led the first Princeton expedition to the fossil fields of Wyoming; or when, after your return from your graduate studies at Cambridge University, you brought the Huxleyan gospel of comparative anatomy to your pupils.

Columbia University has reason to remember the great part you played in planning and guiding the Department of Zoology in its formative period; nor will your old students, either of Princeton or of Columbia, ever forget what new worlds you opened to them and showed them how to enter.

The New York Zoological Society owes to you thirty-one years of brilliant service as chairman of the executive committee and later as its president.

From many parts of the world, therefore, your friends unite to testify their appreciation of your services as a leader in biological science, in education and in the highest ideals of citizenship.

We congratulate you again upon this unique record of service. We delight in the admirable spirit of fairness, generosity, friendliness and comradeship which you have shown, not only to your colleagues but to the least of your assistants. And we rejoice with your devoted wife and your sons, daughters and many grandchildren, that this seventieth birthday finds you with forces unimpaired, still planning, still building, under the inspiration of a dauntless optimism.

SCIENTIFIC NOTES AND NEWS

Svante Arrhenius, director of the Nobel Institute for Physical Chemistry at Stockholm, distinguished for his contributions to physical chemistry, died on October 2, aged sixty-eight years.

Dr. Wilhelm Einthoven, professor of physiology at the University of Leyden, known for his work in cardiac physiology and for the invention of the string galvanometer, died on September 28, aged sixty-seven years. Dr. Einthoven was awarded the Nobel prize in medicine in 1924.

On the occasion of the opening of the new Henry Herbert Wills physics laboratory at the University of

Bristol on October 21 by Sir Ernest Rutherford, the degree of doctor of science *honoris causa* will be conferred upon the following: Professor Max Born (Göttingen), Sir William Bragg (Royal Institution, London), Professor A. S. Eddington (Cambridge), Professor Alfred Fowler (Imperial College of Science and Technology, London), Professor P. Langevin (Paris) and Sir Ernest Rutherford (Cambridge).

THE Reale Accademia dei Lincei has conferred its royal prize in mathematics on Professor Leonida Tonelli, of the University of Bologna. One of the prizes founded by the (Italian) Ministry of Public Instruction has been awarded to Professor Enea Bortolotti, of the Reale Liceo Artistico di Bologna.

SIR CHARLES SHERRINGTON, of the University of Oxford, will address a special meeting of the section of neurology and psychiatry, New York Academy of Medicine, on the evening of October 25.

ON August 15 a banquet was held by the Czechoslovak Academy of Agriculture in honor of its visiting honorary member, Dr. L. O. Howard, of the U. S. Bureau of Entomology. During the banquet, Professor Stoklasa, who acted as toastmaster, spoke in appreciation of Dr. Howard's contributions to entomology.

AT the annual election of the Safety Congress, H. E. Niesz, Chicago, was chosen president and W. H. Cameron, Chicago, was reelected managing director. The following vice-presidents were chosen: E. W. Beck, New York; C. E. Hill, New York; Miller McClintock, Harvard University; C. J. Moore, Longmeadow; C. E. Pettibone, Boston; H. A. Reninger, Allentown, Pa.; G. E. Sanford, Schenectady, N. Y.; A. W. Whiting, New York, and Professor C.-E. A. Winslow, Yale University.

DR. E. H. VOLWILER has been elected chairman of the scientific division of the American Drug Manufacturers' Association.

DR. LEA MCI. LUQUER has been appointed research associate in optical mineralogy at the American Museum of Natural History.

PROFESSOR S. S. STEINBERG, head of the department of civil engineering at the University of Maryland, has resigned as assistant director of the highway research board of the National Research Council, in order to return to his duties at the university and to practice as consulting engineer on road and street construction.

ON September 1, a few months after reaching the age of seventy, Dr. F. S. Kedzie retired from the deanship of the division of applied science of the Michigan State College and became the college historian. Dr. Ernst A. Bessey, head of the department of botany, has been made acting dean in Dr. Kedzie's place, still retaining the headship of the department of botany. Dr. Kedzie as student and as instructor, assistant professor and professor of chemistry, then as president and later as dean has been connected with the Michigan State College for about fifty-three years.

DR. JAMES P. CHAPIN, associate curator of birds in the American Museum of Natural History, returned on September 25, accompanied by De Witt L. Sage, from Central Africa, where they spent eighteen months in the Ruwenzori mountain range and the Kivu, volcano west of the Congo River, collecting birds and small mammals.

PROFESSOR GUSTAV ALEXANDER, of Vienna, has arrived in New York for a brief visit to American medical centers. He will lecture on oto-neurology and on histo-pathology of the internal and middle ear.

PROFESSOR F. C. KRAUSKOPF, of the University of Wisconsin, is on sabbatical leave this semester, which he is spending in studying the methods of teaching freshman chemistry at various institutions in California. Professor E. R. Schierz, of the University of Wyoming, is filling the temporary vacancy occasioned by Dr. Krauskopf's absence.

DR. ELMER LASH, of the U. S. Bureau of Animal Industry, who for several years was stationed in Washington, was transferred to Des Moines, Iowa, on September 6. Dr. Lash will assist in the administration of tuberculosis work in the states of Iowa, Nebraska, Missouri, Minnesota, South Dakota and Kansas.

IT is reported that Dr. Alwin Mittasch, head chemist of the German dye trust and coinventor of synthetic methanol and coal hydrogenation improvements, is leaving for the United States, where he will devote some time to scientific study in collaboration with American industry.

PROFESSOR R. A. LEHFELDT, professor of economics in the University of the Witwatersrand, Johannesburg, since 1917, and formerly professor of physics in East London College and also in the South African School of Mines and Technology, has died, aged fifty-nine years.

THE "John Hampton Hale" research laboratory of the Royal Dental Hospital of London was opened on October 4, by Sir Walter Fletcher, F.R.S.

A LABORATORY for the breeding of beneficial parasites has been opened at Farnham Royal, Bucking-

hamshire, under the direction of the Imperial Bureau of Entomology.

AT the meeting of the international executive committee of the World Power Conference in Cernobbie, on Lake Como, it was decided to hold the next conference in Germany in 1930. It also was decided to hold a sectional meeting in Tokio in 1929.

THE first South African Medical Congress, under the auspices of the Federal Council of the Medical Association of South Africa (British Medical Association), is to be held in Bloemfontein in the week beginning March 12, 1928.

THE Albert Merritt Billings Hospital and the Max Epstein Clinic of the University of Chicago Clinics, was opened to patients on October 3. Formal dedication of the clinics will be held on October 31 and November 1, when distinguished medical men of this country and Europe will be present. Hospital and out-clinic service will be available for cases in general medicine, surgery, eye, ear, nose and throat, and neurology. The new building on the Midway of the Chicago Lying-In Hospital, affiliated with the university, will provide for obstetric cases at a later date. The Charles Gilman Smith Memorial Hospital, to be built soon, will care for contagious diseases; the Bobs Roberts Memorial Hospital for children; and the Gertrude Dunn Hicks Memorial for orthopedic surgery. The Chicago Lying-In Hospital is now engaged in raising the last $400,000 of the one million dollars required for its funds, and gifts have already provided for the construction of the other hospitals.

THE Saint Paul Institute has bought for $250,000 the Merriam residence adjoining the capitol at Saint Paul, Minn., to house the museum that was formerly displayed in rooms of the City's Auditorium. The second floor of the building is given to biology and the third floor to geology. The building stands in the center of a two and a half acre tract which is to be used for expansion of the museum in the future.

THE Massachusetts Institute of Technology has received a large addition to its library in the form of a gift of about 200 complete volumes on chemistry and several sets of chemical journals from Mrs. Henry P. Talbot, widow of the late dean of the institute.

A COLLEGE OF FISHERIES is to be established in Halifax, affiliated with Dalhousie University. The university will give a course in the fundamental sciences, while the Biological Board of Canada will treat of fishery subjects. A government appropriation of $25,000 has been made toward the establishment of a marine laboratory to be located somewhere on the shores of Halifax Harbor, in all probability near the open sea.

THE Paris correspondent of the *Journal* of the American Medical Association reports that the Pasteur Institute has received a legacy of $800,000 from a French physician, Dr. René Marius Appert, of Paris, who died at the age of sixty-five at San Remo, on the Italian Riviera.

ARTHUR WILLIAM SCOTT, M.A., of St. David's College, Lampeter, Cardiganshire, for fifty-five years Phillips professor of science there, who died on March 7, aged eighty-one years, has made the following bequests: £7,000 to the University of Cambridge, the income to be applied for the furtherance of physical science in such manner as the authorities may determine; £500 to Trinity College, Dublin, for the general purposes thereof; £250 each to the British Association for the Advancement of Science, the Physical Society, London ("of which I am a Fellow"), the Institute of Physics, London ("of which I am a Foundation Fellow"); £1,000 to the Royal Society, the income to be applied for the advancement of the physical sciences. And after these and other bequests the residue of the property as to one third to the University of Cambridge, the income therefrom to be applied for the furtherance of physical science; one third to the University of Oxford for like purposes, and one third to St. Thomas's Hospital, London.

BY the will of Mrs. Lilian Horsford Farlow, of Cambridge, widow of the late Professor William G. Farlow, of Harvard University, the income of a $20,000 bequest to Harvard is to be placed at the disposal of the curator of the Farlow Reference Library, to be used for the purchase of suitable books and periodicals on botany. Mrs. Farlow presented the library in the cryptogamic botanical herbarium to Harvard, prior to her death, as a memorial to her husband. Another $5,000 is bequeathed to Harvard, to be used at the discretion of the curator of the library for the purchase of a collection of cryptogamic specimens to be added to the Farlow Herbarium. A bequest of $10,000 to Radcliffe is to be added to the Lilian Horsford Farlow Fund previously established for the college library. The sum of $10,000 is given to Wellesley College to be added to the sabbatical grants established by Mrs. Farlow's late father, Professor Eben Norton Horsford, of Harvard. During her life Mrs. Farlow presented Harvard with $50,000 in memory of her father, the money to be used for the general purposes of the chemical laboratory, where her father was engaged in research work for many years.

THE Associated Press reports that advancement of the study of meteorology from the viewpoint of aviation is the purpose of a committee formed by the Daniel Guggenheim Fund for the promotion of

aeronautics. The committee will make its headquarters in the Weather Bureau in Washington. Its members are C. G. Rossby, representing the fund; Willis R. Gregg, of the Weather Bureau; Major William R. Blair, of the United States Army; Lieutenant F. W. Reichelderfer, of the United States Navy, and Thomas H. Chapman, of the Department of Commerce.

PURCHASE of two additional areas for the New York State park system in the Finger Lakes region has been asked in a resolution addressed to the State Council of Parks by the Finger Lake Parks Commission. The parks recommended are Stoney Brook Glen at Dansville and Red Jacket Park on Cayuga Lake, near Seneca Falls.

INFORMATION received by the U. S. Department of Agriculture shows unusual interest on the part of state legislatures in making appropriations for the eradication of tuberculosis from domestic livestock. The appropriations made by the states, together with approximately $6,000,000 appropriated by the last United States Congress, make available for the ensuing year's work approximately $18,500,000. In addition to the appropriations, valuable new legislation, amending various state laws, is expected to hasten the work in a number of states. This campaign for eradicating tuberculosis in domestic livestock made exceptional progress during the fiscal year ended June 30, 1927. Records of the Bureau of Animal Industry show that 347 counties have completed the necessary official tests and have qualified for recognition as tuberculosis-free areas. This number constitutes more than 11 per cent. of the total number of counties in the United States. In addition 945 counties were actively engaged in the area project at the beginning of the current fiscal year.

AT the Leeds meeting of the British Association, as we learn from *Nature,* the council reported two conferences called to consider the possibility of establishing a Science News Service. The essential condition for success of such a scheme was said to be that scientific societies and institutions themselves should desire its organization. In view of the lack of unanimity and of enthusiasm evinced at the two conferences, the committee appointed to indicate the ways in which this support might be given considers that no useful purpose would be served by communicating with the scientific societies. The opinion is expressed, however, that should sufficient funds be forthcoming for the establishment of a Science News Service, the council of the association—possibly in cooperation with the British Science Guild—might appropriately undertake the organization of the service.

UNIVERSITY professors from various European countries were present at a meeting held in the Kurhaus at Davos (Switzerland) in support of a scheme for founding, at Davos, an Alpine University of an international character for students in delicate health. It is stated that there are, in Europe alone, over 15,000 university students suffering from tuberculosis. It was decided to hold another conference at Celerina, in the Engadine.

DATA available for 1926 to the health section of the League of Nations indicate that the birth rate in many countries continues to decrease, and is likely to continue to do so for a number of years. The area of low birth rate (between 17 and 20 per thousand) now includes almost the whole of northern, western and central Europe. The birth rate is still between 35 and 40 in eastern Europe; it now is lower in Sweden and in England than in France.

THE summary of progress of the geological survey of Great Britain and the Museum of Practical Geology for the year 1926 has been published. The board states that highly satisfactory progress was made during the year, both in field work and indoor work. The resurvey of coalfield areas has been pressed forward energetically. In most of the British coalfields revision of the six-inch maps is being carried on and 64 maps were published during the year, showing the latest geological information and in many cases accompanied by descriptive memoirs. Efforts have been made to render geological drift mapping of greater assistance to agriculturists. Concern is expressed by the board that for financial reasons no provision has been made in the estimates of the Office of Works for the erection of the new building for the Geological Survey and Museum at South Kensington. They consider the erection of the new building at the earliest possible date essential to the adequate preservation and presentation of the records. Geological investigations in the Yorkshire coalfield, the Surrey Downs and the Isle of Man and new methods of investigating deep structures by means of the Eotvos balance are among the matters dealt with in the appendices.

INVESTIGATIONS covering Tennessee, Arkansas, Mississippi and Louisiana by Dr. Joseph Goldberger and Edgar Sydenstricker, under the auspices of the U. S. Public Health Service, indicate an increase in pellagra due to causes related to the recent floods. From the survey made, it was estimated that pellagra, during 1927, will cause from 2,300 to an estimated total of about 2,500 deaths, with from 45,000 to 50,000 cases, as compared with 1,020 deaths and 20,000

cases reported in 1924. In the course of the survey, these investigators visited Dyersburg and vicinity, Tenn.; Little Rock, Pine Bluff, Marked Tree and vicinities, Ark.; Jackson, Greenwood and Indianola, Miss.; and New Orleans, Baton Rouge, Alexandria and Monroe in Louisiana. Conferences were held with state and local health officials, some of whom do not seem to have definite information concerning the pellagra situation. The information obtained was therefore of a very general character with regard to some communities, and in at least one community, very definite. The authorities are satisfied that in the places visited the incidence of pellagra is abnormally high.

THE Associated Press reported on August 23 that intense activity of Bogoslof island, a volcano peak in the Western Aleutian islands, which rose from the sea May 18, 1796, was reported by Henning Plaun, Danish consul in Seattle, recently, after completing a trading trip to Ust, Siberia. He said the volcano appeared as though it would explode like a giant firecracker. "We went within three miles of the island," Plaun said. "The entire island seemed afire. Smoke and steam was issuing from every part of the island, and many huge cracks could be seen. Hundreds of sea-lions were in the water off the island roaring as if in protest to the burning of their home. We could hear their roaring for six miles." Thousands of birds swarmed about the island. The water was discolored and a strong smell of sulphur was in the air. Cable advices from Dutch Harbor, Alaska, last month reported that Dr. T. A. Jaggar, volcanologist from Hawaii, making an investigation for the United States Geological Survey, saw twenty large volcanoes in action in the Western Aleutian islands. Dr. Jaggar at that time expressed the opinion a new spell of intense activity resembling the eruptions of 1906 was in progress. Both Bogoslof and Fire island, which arose nearby in 1883, have spasmodically erupted, being joined and separated several times by the rising and lowering of the bottom of the sea.

THE Société des Amis de l'Université de Paris, at its last general assembly, under the chairmanship of M. Raymond Poincaré, decided to donate considerable sums to various laboratories. M. Paul Appell, honorary rector of the Académie de Paris, whose fiftieth anniversary as a scientific worker was recently celebrated, presented a gift for the purchase of books for the students' study hall. Several other gifts were made for special purposes. M. David Weil gave $4,000 to be applied to the cost of printing theses presented by candidates for the doctor's degree at the Faculté des sciences and the Faculté des lettres. This donation is important because some students are unable to complete their graduation requirements because of the high cost of printing. The funds furnished for this purpose by the Institute de France, the central government and Madame la Marquise Arconati Visconti have been exhausted.

A CHEMICAL exposition will be held at Turin under the auspices of and supported by the Italian Government. The exposition will last six months and will be confined to the national industry in the case of chemical products, but will be international as regards machinery and apparatus for the chemical industry, the following types of which are to be exhibited: (a) Pulverization and mixing, sieving, heating ovens and industrial processes, filtering, evaporating, distillation, crystallization, sublimation, centrifugal machines, suction plants, compressors, vacuums lignification of gas, compressed gases, drums, etc. (b) Combustion gassification. (c) Containers. (d) Refrigerators, ice machines and refrigerating machinery of all kinds.

THE Danish Arctic explorer, Dr. Lauge Koch, accompanied by the Cambridge geologist, Mr. Harris, and the Danish geologist, M. Rosenkrantz, have returned to Copenhagen on board the *Gustav Holm* from Scoresby Sound, the base for the scientific expedition which went to East Greenland in 1926. After an autumn reconnoitering trip as far as Mackenzie Bay, Dr. Koch, with three Eskimos, left on February 22 on a sledge journey with dogs of over 1,550 miles to Denmark Harbor. The journey was extremely difficult owing to heavy snow. The party reached Denmark Harbour on April 8, starting back the same day. Mr. Harris and M. Rosenkrantz, who had remained at Scoresby Sound, collected eight tons of fossils, the largest Arctic collection ever brought home. Mr. Harris collected fossilized palms from Greenland's tropical period and M. Rosenkrantz especially animal fossils, including a particularly beautiful ammonite, a yard in diameter. They also found large quantities of coal in easily workable layers, but no precious metals. In the neighborhood of Scoresby Sound many active hot springs and inactive volcanoes of about the same age as those of Iceland were discovered.

UNIVERSITY AND EDUCATIONAL NOTES

IT is announced that Trinity College, Connecticut, will construct a new laboratory for chemistry, at a cost of $350,000, as soon as plans for the building can be prepared.

AN engineering laboratory, to cost about $100,000, in addition to equipment, will be erected at Haverford

College during the next college year as a memorial to T. Allen Hilles, of Wilmington, Del., a graduate of the class of 1870.

A CHECK for $50,000, the gift of Cyrus H. K. Curtis, of Philadelphia, to Milwaukee-Downer College has been presented to the board of trustees to be used for the equipment of the science building now under construction.

DR. HENRY SPENCER HOUGHTON has been appointed dean of the Medical School of the Iowa State University.

DR. FREDERICK H. HOWARD, professor of physiology at Williams College, has been appointed professor of physiology at the College of Physicians and Surgeons, Columbia University.

AT the University of California, E. O. Essig has been appointed professor of entomology and entomologist of the Agricultural Experiment Station. Dr. Edwin C. Van Dyke has been appointed professor of entomology.

DR. MATILDA MOLDENHAUER BROOKS, formerly associate biologist of the Hygienic Laboratory at Washington, D. C., has been appointed research associate in biology at the University of California.

DR. THEODORE KOPPANYI, of the department of physiology of the University of Chicago, has been appointed assistant professor of pharmacology in the college of medicine at Syracuse University.

PROMOTIONS in the department of chemistry of the University of Pittsburgh have been made as follows: Drs. H. E. Woodward, F. Y. Herron and J. N. Roche, from graduate assistant to instructor; in the department of physics, Dr. Oswald Blackwood, from associate professor to professor, and Dr. Elmer Hutchisson, from instructor to assistant professor; in the department of botany, Dr. A. B. Wallgren, from assistant professor to associate professor.

THE vacancy in the electrical engineering faculty of Case School of Applied Science, created by the death of Dr. Huxley, will be filled by Dr. P. L. Hoover, research fellow in electrical engineering at Harvard University, who has been appointed assistant professor of electrical engineering.

PROMOTIONS at Yale University include the following: Dr. Edwin H. Lockwood, Robert Higgin professor of mechanical engineering; Dr. James D. Trask, associate professor of pediatrics; Dr. Willard B. Soper, associate clinical professor of medicine; Dr. Edwin J. Fisher, assistant professor of chemistry; Dr. Sidney M. Newhall, assistant professor of psychology, and Dr. Albert F. Hill, assistant professor of botany.

DISCUSSION AND CORRESPONDENCE

THE INFLUENCE OF ADRENAL EXTRACTS ON THE SURVIVAL PERIOD OF ADRENALECTOMIZED DOGS[1]

UNTIL it has been shown that any adrenal extracts whatever possess the power of definitely increasing the period of survival after removal of the adrenals, the assumption that the cortex produces a "hormone" (which might appropriately be termed interrenalin) must lack a foundation, and attempts to isolate and purify such a body can hardly be made with confidence. We have used extracts, made from dog's fresh adrenals with 0.9 per cent. salt solution and glycerine. The clear extracts were injected intravenously on alternate days. The injections produced no obvious ill effects.

The only criterion at present at our disposal to determine the efficacy of an extract is its effect on the survival period. This is a very severe test because of the fact that all the important derangements which eventually lead to death must be neutralized by the substance. If changes not of themselves causing death could be associated with the loss of the adrenals, it might be easier to obtain evidence of the existence in extracts of a body or bodies capable of preventing them.

It is obvious that in drawing conclusions as to the effect of any method of treatment upon the period of survival, it is essential to have a sufficiently large number of "control" animals. We have accumulated more than a hundred control dogs, so that it may be said with confidence that we know the limits of the survival period in dogs doubly adrenalectomized and not subjected to any treatment. Of course, this series of control animals is necessary and available for many other researches. The majority of the animals lived about a week to 10 days, a good many less than a week. About 8 per cent. survived a fortnight or somewhat longer. The longest survival period was 16¼ days (one dog).

Among about 30 dogs treated with extracts, one lived into the 18th day, one into the 20th day, one into the 22nd day, one into the 23rd day, one into the 28th day, and one survived 78 days after removal of the second adrenal. Nothing like those results were seen among the much larger number of control dogs. It is impossible to draw any other conclusion than that the extracts in some way prolonged the life of the animals in the absence of the adrenals. The rest of the treated animals compared favorably with the controls as regards duration of survival. As the extracts injected into the different animals were often obtained from different adrenals, it is easily understood that their potency would vary.

[1] From the H. K. Cushing Laboratory of Experimental Medicine, Western Reserve University.

There is no reason to suppose that the epinephrin, present in larger or smaller amount in the extracts, could have had any appreciable influence in prolonging life. No effect of this kind was observed when epinephrin equal to the maximum amount which could have been contained in the dose, given on the assumption that none of it had been destroyed, was injected. Much of the epinephrin was destroyed in making the extract.

J. M. ROGOFF
G. N. STEWART

WESTERN RESERVE UNIVERSITY

AN INQUIRY INTO THE MOTION OF DROPLETS OF JUICE EJECTED FROM AN ORANGE[1]

WHEN an orange is divided into hemispheres and eaten with a spoon, it has often been observed that droplets of the juice emerge and proceed with extraordinary rapidity and uncanny accuracy into the eye of the observer. The phenomenon is a subtle one and explanations which have been offered are conflicting, so that recently certain experiments have been undertaken with a view to its elucidation. Although much remains to be done, it is believed that the results obtained are of sufficient importance to warrant a preliminary report at this time.

Earlier observations in this field, rather sketchy perhaps, may be mentioned briefly. Adam[2] is recorded as saying "damn" violently at the breakfast table (with, of course, the inevitable remonstrance from Eve). This may be regarded as very precise evidence that the oranges of that epoch delivered their droplets with unerring aim. Although the conditions were not quite the same the fact was evidently well known to Atlanta[3] who dropped oranges (the Greek word is ωραμσε, wrongly interpreted by the commentators as "apple") in the path of her competitors in races, thereby removing them from the competition. More recently the Spanish Dons were wont to present oranges to their ladies with a view to rendering them incapable of choosing other partners. In the late war no doubt only the high visibility of oranges prevented them from being used in the most bitter offensives.

In the present experiments a large concave ladle, 2,000 karat, served as a source of energy. The crossed fields were impressed by a cuneiform magnet, the usual precautions being observed when adding the cracked ice. It was soon found absolutely necessary to apply a relativity correction. This was done, however, carefully in Latin so as not to injure any of the finer sensibilities, if there were such present.

The results of the measurements showed that the diameters of the droplets were of the order of 10^{-21} cm, which accounts for their being able to enter the smallest crevice of the eye. Their speeds varied over a considerable range, but on the whole were high, averaging about a tenth of the velocity of light. It was found that the droplets were attracted towards the eye with a force varying with the inverse seventh power of the distance. These facts are all seen to be but details bearing out the surprising frequency with which the droplets steer for the eye, and are best explained by an appeal to the 1st law, *i.e.*, the innate cussedness of inanimate things. An exhausting series of experiments developed the remarkable fact that the right hand invariably propels the droplets into the left eye. A little thought, however, indicated that this was so because the right hand didn't wish the left to know what it was doing.

It is hoped to present in a future paper a mathematical explanation based on the flirtation theory of Einwein and Drinkemoffski.

E. O. HULBURT

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USE AND DISUSE IN THE CHROMOSOMES

THE writer expressed his theory of use and disuse in the chromosomes as an explanation of phylogenetic development in the article "Factors in Phylogenetic Development" in the May–June, 1927, number of the *American Naturalist*. Further study of the principles expressed in this paper has led to the conclusion that the uniformity of genes in the various parts of the body need not be limited to the coordinative forces of the organism, although coordination is an obvious essential to such uniformity.

Since the chromosome complex characteristic of the species persists in most cells of the body, it follows that most cells contain a great number of genes which find no expression within those cells. It seems improbable that the millions of genes in this category are entirely without effect in the expression of inherited characters.

The only logical interpretation of this condition is then that a given character is the product of certain genes not merely in the cells taking part in the expression of the character but throughout the body. According to this view the distribution and influence of genes are not coincident. The development of a cell may be due to the influence of a multitude of genes rather than of one or a few within itself, and consequently any increase in the functional capacity of a gene due to repeated use would be at the outset an attribute of all genes of that kind throughout the

[1] Read before the Royal Society of Sultry Yachtsmen.
[2] Eden "Scientific Papers," 1, 35 (6721 B. C.).
[3] Homer, Canto 7.

dy, primordial germ cells included, since they are bject to the coordinating mechanism of the or- nism.

On this basis there can be no possible question of e association of somatic characters with the germ- lls. It has been shown that any character which s significance in evolution is already a part of the ritage at least to the extent that it is a product of herited functional capacity responding to some con- tion within or without the organism. If we are stified in the interpretation of the functions of genes re expressed, any change in functional capacity ac- ruing from use or disuse is no less a part of the ritage.

A. W. LINDSEY

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TYPE CULTURES

A COMPLETE catalogue has been issued by the American Type Culture Collection. This catalogue can be obtained upon request to the Curator, American Type Culture Collection, John McCormick Institute for Infectious Diseases, 637 S. Wood Street, Chicago, Illinois. The collection now contains about 1,450 cultures including 256 fungi and 200 yeasts. A charge is made for cultures to help defray the cost of maintaining the collection.

L. A. ROGERS
Chairman, Executive Committee

THE ORIGIN OF THE PRAIRIE

A PHENOMENON heretofore unsatisfactorily explained by scientists is the occurrence of the natural grasslands of the Middle West, particularly the extensive prairies of Illinois, Indiana and Iowa. Though most of the theories advanced explain their existence altogether in terms of present physical conditions, I am convinced that rapid drainage prevailing at the time of their origin is a determining factor in their development.

It is generally agreed that lakes or marshes are destined in the course of time to become either forest or prairie. One of the factors which may determine which of these shall be the ultimate stage has not been reported. It has come to my observation that if lakes or marshes are drained quickly prairie develops, if drained slowly forest develops. This relationship occurred to me after I had observed small ponds in Albemarle County in Piedmont, Virginia, for a period extending over twenty-five years. One pond observed was that on my father's land near North Garden, Virginia, which was built in 1888 by filling the lower end of a ravine with dirt and pine brush. This ravine contained a small stream which rose at the foot of a forest made principally of poplars (*Populus balsamifera*), black locust (*Robinia*), white (*Quercus alba*), red (*Quercus rubra*) and black (*Quercus velutina*) oaks. The pond, however, was more directly surrounded by a jack pine (*Pinus virginiana*) forest. Black porters loam soil had been washed down into the pond from the forest mentioned first until there was a deposit of two and one half feet and the pond was then left two feet deep. In the summer of 1904 the dam of the North Garden Pond was broken by a storm. The succeeding vegetation was grass, in which no seedling trees appeared. Though the dam was rebuilt in 1905, since then the pond has been neglected. Due probably to slow leakage caused by crayfish, the water level of the dam has been gradually falling. Following this gradual drainage, the exposed edges have been passing through the willow (*Salix nigra, Salix longifolia*) and cattail (*Typha*) into the pine (*Pinus virginiana*) stage without the intervention of grass.

Another pond observed through a period of years was the Coles Pond on top of Green Mountain, 1,000 feet above sea-level, and surrounded by a virgin oak forest consisting mainly of white (*Quercus alba*) and black (*Quercus velutina*) oaks. The pond was made by an artificial mound of dirt between two hills. When I first saw this pond in 1901 it was covered with coarse grass. Mr. Butler, the manager of Stutsville (the name of the farm), informed me it was broken two years previously by the water after a thunder storm. Mr. Butler refilled the pond in the fall of 1901. Since then it has been gradually drained by seepage. Algae first appeared on the edges such as *Oscillatoria, Spirogyra, Oedogonium* and *Vacheria,* followed by mosses on the edge, but not sphagnum. As the water level dropped, these were replaced in the following sequence: cattail (*Typha*), bottombush (*Cephalanthus occidentalis*), black willow (*Salix nigra*), sand-bar willow (*Salix longifolia*), maple (*Acer saccharinum*), jack pine (*Pinus virginiana*), and at the present time the black oak (*Quercus velutina*), red oak (*Quercus rubra*), sassafras, *Vertifolium,* intermingled with wild grape (*Vitris vulpina*).

Recently, further study under Dr. H. C. Cowles in the Chicago region has provided additional data. Prairies, for example, are developing to-day from Calumet Lake near Chicago. Sedges are encroaching rapidly upon the bulrushes as the new soil is gradually raised higher and higher above the lake, and in turn the encroaching of grasses upon the sedges is resulting in a prairie. Skokie marsh and hog marsh are also undergoing transformation of this character. Sometimes with the prairie grasses are a number of

coarse xerophytic herbs, largely composites (*Silphium laciniatum, S. terebenthinaceum, S. integrifolium, Lepachys, Solidago rigida, Aster, Liatris*), with legumes (*Amorpha canescens,* Petalostemon, Melilotus, Baptisia), and Eryngium, Dodocatheon, Phlox and *Allium cernuum.* These prairies are being formed from the basin of the former glacial Lake Chicago.

The formation of natural grass and forest regions in the Chicago region may be explained by a study of its glacial history. While the edge of the ice in the last advance was being melted back to the Valparaiso moraine and while it remained there, glacial water flowed off to the south. From northern Illinois this found its way by various valleys to the Mississippi. As the ice retreated farther to the northeast of the Valparaiso moraine, the depression between the ice front and the morainic ridge was flooded with the glacial water. The Lake Chicago so formed gradually enlarged as the edge of the ice retreated. Its waters rose until they reached a level of about sixty feet above the present surface of Lake Michigan.

At this stage Stony Island was completely submerged. When the outlet of Lake Chicago was lowered, it entered upon a second stage twenty feet below the first, but Stony Island was still under the water. As the outlet was lowered further the lake level fell to the third stage (the Tolleston stage), which exposed the very top of Stony Island. By the breaking of the waves a beach ridge was formed on top of the island and at this time the forest began its growth. Then when the ice sheet melted away and an outlet was established by way of the St. Lawrence Valley, the old lake fell to the present level of Lake Michigan, and the surroundings of Stony Island became land. These surroundings, rapidly drained, are to-day grassland, while Stony Island itself is practically covered with forest.

I believe furthermore that the grasses in the prairies are not a climax stage, but that the forests are gradually encroaching upon them. This process is very slow because the grass, when once firmly established, forms a mat which prevents the seeds of trees from getting into the soil and germinating. There are conditions, however, which aid the forest seeds in securing a place in the grass-covered soil. For example, disturbances of that mat are caused by man's digging or plowing, horses pawing the earth and erosion by running water. If tree seeds once fall in such places they will germinate and if undisturbed will grow. This would explain the presence of trees, either in patches or scattered throughout an area once covered with grass. Indeed, the savannah may be accounted for in such a manner.

The help of eroding forces in the formation of forest may be further shown by observation of sand dunes. Here the instability of the soil is preventing the grass from forming a mat, and forests are slowly encroaching upon the dunes, securing a foothold before a grass mat can be formed.

In view of the above observations, I am of the opinion that the natural prairies of the Middle West are due not to present physical conditions but to rapid drainage at the close of the ice age. Further I believe that the grass stage thus formed is not the climax, but that trees are slowly invading the prairies, being aided in their progress by erosive processes.

Philip M. Jones
The Pennsylvania State College

SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE PREPARATION OF COPPER HYDROSOL AND ITS USE IN ELECTROPLATING OF GLASSWARE[1]

Some time ago the author found it necessary to copper plate the bore of some capillary tubing. For technical reasons, a basic layer of another metal or of graphite was undesirable, even had it been possible to apply the latter. Cathodal deposition was also out of the question.

By employing hydrazine hydroxide as a reducing agent a suitable copper hydrosol was prepared. Gutbier found hydrazine hydroxide in 1–4,000 dilution sufficient for formation of the blue gold hydrosol[2] but since copper is immediately below hydrogen in the electromotive table a much stronger solution was found necessary in this case.

Method.—An article to be plated is well cleaned—that process followed by Brashear in his silver plating method[3] should be satisfactory. It is then placed in a receptacle of just sufficient diameter to accommodate it and covered with a 50 per cent. aqueous solution of hydrazine hydroxide. (It is not necessary to prepare this from the salt—it appears to keep indefinitely when placed in the dark. After some months there may be a faint odor of ammonia, but there is no appreciable reduction in concentration.) To this is added, drop by drop and with constant vigorous shaking, a 5 per cent. solution of cupric sulphate until a deep golden suspension of colloidal copper is obtained. One or two drops of excess are then added and metallic copper is de-

[1] From The Hull Physiological Laboratories of The University of Chicago.

[2] Gutbier, *Zeit. für Anorg. Chem.* 1902.

[3] Brashear, Miller's Laboratory Physics. Ginn & Co.

ited as a thin film upon the surface of the article the walls of the container. This film may serve a support and conduction pathway for a subsequent layer of electrolytically deposited copper.

The method finds some objection in the expense the reducing agent employed.

The reaction is simply the formation of cupric droxide and its immediate reduction by the excess hydrazine.

$$CuSO_4 \quad N_2H_4 2H_2O \quad Cu(OH)_2 \quad N_2H_6SO_4$$
$$2Cu(OH)_2 \quad N_2H_4 \cdot 2H_2O \quad 2Cu \quad N_2 \quad 6H_2O$$

The rapidity of the reaction allows for the formation of a hydrosol which gradually precipitates due the presence of the bivalent SO_4 ion. When a spension of cupric hydroxide is used instead of e sulphate the precipitation is much slower.

However, the same effect is obtained by addition an alkali to the hydrazide of copper. This subance, prepared by treatment of potassium hydrazine rbonate with dilute copper sulphate, is a blue, morphous, insoluble powder, of empirical formula N_2H_6. It shows all the qualitative reactions of a ydrazide.

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SPECIAL ARTICLES

ON THE APPARENT LARGE DIAMETERS OF MOLECULES FOR DEACTIVATION BY COLLISION

A RECENT paper by Tolman, Yost and Dickinson[1], devoted mainly to a criticism of some of the underlying physical assumptions made by Fowler and Rideal[2] in a theoretical study dealing with the rate of maximum activation by collision for complex molecules, with particular reference to its application to velocities of gas reactions, takes up the question of the apparent large diameters for deactivation-collisions to which the latter theory seems to lead.

The purpose of this note, in addition to one or two other observations, is to point out an error in Tolman, Yost and Dickinson's calculation on N_2O_5. In agreement with Fowler and Rideal they show that the fraction of molecules possessing energy greater than ε_0 in a system containing N molecules per c. c. each molecule having s variables (coordinates or momenta) which contribute classical square terms to the internal energy, is

$$N_{act.} = N \frac{1}{\Gamma(\frac{1}{2}s)} \left(\frac{\varepsilon_0}{kT}\right)^{\frac{1}{2}s-1} e^{-\frac{\varepsilon_0}{kT}}$$

[1] Proc. Nat. Acad. of Sci. *13*, 188, 1927.

[2] Proc. Roy. Soc. *113*, 571, 1927.

If the maximum possible rate of deactivation by collision with unactivated molecules is given by

$$Z_{deact.} = 4 N N_{act.} \sigma^{*2} \left[\frac{\pi kT}{m}\right.$$

and if the principle of microscopic equilibrium holds, the maximum possible rate of activation by collision with unactivated molecules according to these authors, is given by

$$Z_{act.} = 4 N^2 \sigma^{*2} \left[\frac{\pi kT}{m}\right. \frac{1}{\Gamma(\frac{1}{2}s)} \left(\frac{\varepsilon_0}{kT}\right)^{\frac{1}{2}s-1} e^{-\frac{\varepsilon_0}{kT}}$$

σ^* being the mean diameter for a deactivation by collision. ε_0 is connected with the heat of activation q in the Arrhenius expression by the relation

$$\varepsilon_0 = q + (\tfrac{1}{2}s - 1)kT$$

$s = 14$; $T = 300°K$; $Q = 24{,}700$ calories; $\frac{Q}{RT} = \frac{q}{kT} = 41.5$; and $\frac{\varepsilon_0}{kT} = 47.5$. By substitution one obtains for the rate of activation:

$$Z_{act.} = 4 N^2 \sigma^{*2} \left[\frac{\pi \times 8.3 \times 10^7 \times 300}{108}\right. \left(\frac{1}{6!}\right)\left(47.5\right)^6 e^{-6} . e^{-\frac{Q}{RT}}$$

$$= 4.25 \times 10^9 \sigma^{*2} N^2 e^{-\frac{Q}{RT}}$$

The rate of decomposition as found by Hirst and Rideal[3] is

$$2.53 \times 10^{14} N e^{-\frac{Q}{RT}}$$

taking $N = 1.615 \times 10^{15}$ molecules per c. c. at 0.05 mm. Hg. and 300°K. and assuming equality in the two rates,

$$\sigma^* = 6.07 \times 10^{-6} \text{ cm.}$$

or about 15 times that to be expected from kinetic theory values. Tolman, Yost and Dickinson's value for the same calculation is 4.7×10^{-4} cms. or nearly 1,000 times greater than kinetic theory values. The difficulties they point out with respect to large diameters are thus greatly reduced in significance especially when we remember that several other cases of large effective radii are known. MacNair[4] calculates the effective diameter of excited Cd atoms as 3×10^{-6} cms. from observations on depolarization effects. By comparing the per cent. of polarization of D_2 resonance radiation in sodium vapor at 10^{-6} mm. pressure excited by polarized light, with that predicted by the Heisenberg theory, Datta[5] finds that the effective diameter of the colliding atoms is of the order of magnitude 10^{-4} cm. or over 1,000 times the kinetic theory value. Similarly Schütz[6] calculates the effective diameter of a collision between normal mercury atoms and mercury atoms in

[3] Proc. Roy. Soc. *109*, 526, 1925.

[4] Phys. Rev. *29*, 677, 1927.

[5] Zeit. f. Physik. *37*, 625, 1926.

[6] Zeit. f. Physik. *34*, 260, 1925.